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The Tactical Environmental Support System, third generation, TESS(3), is the U.S. Navy's newly developed computer workstation for both ashore and afloat sites. The TESS(3) computer system is interfaced to the Navy's Antenna Meteorological Data Receiver-Recorder, AN/SMQ-11. The SMQ-11 acquires satellite data from the Defense Meteorological Satellite Program (DMSP) and the National Oceanic and Atmospheric (NOAA) polar orbiting satellites. Weather facsimile (WEFAX) transmissions from the Geostationary Operational Environmental Satellite (GOES) are also received with the SMQ-11.

TESS(3) has two disks dedicated to satellite data in contiguous format for real time data acquisition. Each 384MB disk is capable of storing 1 DMSP, 1 NOAA, 1 DMSP OR NOAA 14 minute pass and 4 four minute WEFAX transmissions. In addition, the special sensor data, such as the Special Sensor Microwave/Imager (SSM/I) and the TIROS Operational Vertical Sounder (TOVS), are stored on these satellite data disks.

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SATELLITE CLOUD ANALYSES: A NOWCASTING CAPABILITY FOR THE U.S. NAVY'S TESS(3)

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1. THE U.S. NAVY'S TESS(3)

The Tactical Environmental Support System, third generation, TESS(3), is the U.S. Navy's newly developed computer workstation for both ashore and afloat sites. The TESS(3) computer system is interfaced to the Navy's Antenna Meteorological Data Receiver-Recorder, AN/SMQ-11. The SMQ-11 acquires satellite data from the Defense Meteorological Satellite Program (DMSP) and the National Oceanic and Atmospheric Administration (NOAA) polar orbiting satellites. Weather facsimile (WEFAX) transmissions from the Geostationary Operational Environmental Satellite (GOES) are also received with the SMQ-11.

TESS(3) has two disks dedicated to satellite data in contiguous format for real time data acquisition. Each 384MB disk is capable of storing 1 DMSP, 1 NOAA, 1 DMSP or NOAA 14 minute pass and 4 four minute WEFAX transmissions. In addition, the special sensor data, such as the Special Sensor Microwave/ Imager (SSM/I) and the TIROS Operational Vertical Sounder (TOVS), are stored on these satellite data disks.

As part of the TESS(3) system, satellite data may be overlaid with grid field data and/or observational data, contours or a surface analysis may be drawn or overlaid. The satellite data may also be interrogated for location or temperature and arithmetic calculations may be performed on different channels. The image may be retrieved to an 8, 6 or 4 bit representation and then enhanced.

The basic tools to retrieve, display, enhance and draw onsatellite data are available within the Forecaster functions. A host of non satellite application programs which include meteorological, oceanographic, acoustic and electromagnetic programs are available in an Applications Menu.

The satellite Multichannel Sea Surface Temperature algorithm as well as the Satellite Cloud Analyses software are the first two satellite application programs to reside on TESS(3). This paper describes, in detail, the inner workings of the Satellite Cloud Analyses software.

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2. OBJECTIVE

Real-time environmental satellite data provides the most up-to-the-minute information on the mesoscale conditions available today. However, there needs to exist a means in which to filter, condense or interpret the massive amounts of satellite data into a coherent, concise piece of information or product that tactical decision makers can utilize.

The Satellite Cloud Analyses uses information from multiple sensors, at different resolutions: spectrally, spatially and temporally, and combines and displays the information to the forecaster as a 1024 x 1024 pixel image. The Satellite Cloud Analyses software is used by a forecaster to determine the cloud conditions. These conditions include but are not limited to: cloud top height and temperature, cloud type and cloud amount, moisture parameters, and the area in the image which is a particular temperature or range of temperatures.

3. SATELLITE CLOUD ANALYSES

3.1 Overall Design

This software is selected or activated from the TESS(3) Forecaster Menu in the Work Area Operations Functions. The operator is prompted to choose either DMSP or NOAA satellite data. Once a satellite type is chosen for retrival, the entire pass is retrieved, subsampled and displayed on the screen. The operator, with a trackball, selects the location for the cloud analyses. That location is the center of a 1024 x 1024 satellite image.

The operator has three options: 1) cloud classification, 2) temperature field analyses or 3) multispectral image (NOAA passes only). The following 3 paragraphs describe each of these options.

Cloud classification operates differently for NOAA and DMSP as well as in day or night. This is a box classifier method which places a pixel in a particular cloud class based on its temperature, albedo, delta temperature and the standard deviation of the pixel's eight neighbors.

The temperature field analysis is interactive and allows the operator a tool box to discriminate additional features in the thermal image. There are eight possible enhancements. They are as follows: 1) exponential, 2) logarithmic, 3) linear, 4) invert, 5) histogram equalization, 6) arctangent, 7) sawtooth and 8) sine. In addition to those enhancements are the temperature threshold slicing capabilities. The operator may choose single pixel slicing, or a temperature band or interval to slice, or an all pixels warmer or colder slice.

The third option in the cloud analyses is the multispectral imaging for NOAA only. This option displays three different spectral bands at one time. This option is for the more experienced satellite image interpreter. This multispectral capability is a color composite, displaying three sources of information at once.

On the cloud classification image as well as the multispectral image an overlay of supplemental sensor data is possible. The supplemental sensors provide the moisture parameters: water vapor, liquid water and cloud water derived from the SSM/I as well as cloud top height and temperature derived from TOVS and the IR data.

3.2 Satellite Sensors

The Satellite Cloud Analyses software utilizes the Advanced Very High Resolution Radiometer (AVHRR) and the OperationalLinescan System (OLS) as well as TOVS and SSM/I data. These sensors have different spatial and spectral resolutions. The AVHRR visible and infrared data have 1.1 km resolution at nadir. The OLS data have spatial resolutions for smooth data at 2.78 km and fine resolution data at .56 km. Both the AVHRR and the OLS data are used in a box classifier algorithm to categorize each picture element or pixel, into a cloud type.

A cloud type image is overlaid with a pattern of boxes which represent the TOVS retrieval data at 56 km resolution. The operator may interrogate a cloud pixel for additional information by using a trackball. The software searches the database for the TOVS sounding requested in order to display a cloud top height and takes the IR temperature from the AVHRR IR channel. In addition, the capability exists to overlay SSM/I data (water vapor, cloud water and/or liquid cloud water) at 25 km resolution on top of the height and temperature field and/or on top of the classified cloud image.

These capabilities allow the operator or forecaster, to assess the cloud conditions in their immediate area (up to ~1000 km^2) minutes after receiving satellite data. With these pieces of information, cloud type, height and temperature, and moisture variables, the operator has a better understanding of the current weather with respect to icing, turbulence and precipitation.

4. PLANNED IMPROVEMENTS

The Satellite Cloud Analyses software has the greatest potential for improvement in the cloud classification area. Currently, this box classifier has defined thresholds for the mid latitude and tropical areas. There are thresholds for infrared, visible, IR channel differences and standard deviations to discriminate between stratiform and cumuliform clouds. Sets of thresholds for different seasons as well as for the polar regions are needed.

The overlay of the moisture parameters from the SSM/I would have added utility as a contour field versus a labelled field of numbers. Overall the Satellite Cloud Analyses would be improved by incorporating the moisture parameters with either the 85 GHz channel of the SSM/I or rainrate parameter to produce rain fields.